STRUCTURAL CALCULATIONS FOR PRECAST SLAB UNIT DESIGN BROADWAY RD OVER RWCD

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1

project WIDEN BROADWAY ROAD BRIDGE no. 83039
client CITY OF MESA design R.T. date 5-30-84
subject checked date

STRUCTURAL CALCULATIONS

FOR

PRECAST SLAB UNIT DESIGN
BROADWAY RD. OVER R.W.C.D.
MESA ARIZONA

RGA NO. 83039

CLIENT

CITY OF MESA

Registered Professional Engineer (Structural)
CERTIFICATE NO. 12991
RAYMOND D. TROYER
Date Signed 5-30-84
ARIZONA, U.S.A.

consulting engineers

project WIDEN BROADWAY RD @ RWCD no. 83039
client CITY OF MESA design RT date 5/84
subject checked date

INDEX

SUBJECT	PAGE
I. CRITERIA	1
II. GEOMETRY	2
III. 4'-0" UNIT	4
IV 3'-0" UNIT	13

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project WIDEN BROADWAY RD. BRIDGE no. 83039
client CITY OF MESA design RT date 5/84
subject GIRDER DESIGN checked date

I. CRITERIA

A. CODE - AASHTO 1977 INCLUDING INTERIMS THRU 1983

B. LOADING - HS20

C. MATERIALS

1. CLASS "A" CONCRETE $f'_c = 3000$ psi
   (ABUTMENTS, DRILLED SHAFTS, APPROACH SLAB)

2. CLASS "S" CONCRETE $f'_c = 5000$ psi
   (Std. P/S VOIDED SLABS)

3. REINFORCING STEEL
   a. ASTM A615, GRD. 40
      (CIP CONCRETE)
   b. ASTM A615, GRD. 60
      (P/S)

4. PRESTRESSING STEEL
   1/2"Ø 7 WIRE ASTM A416 $f'_s = 270$ KSI

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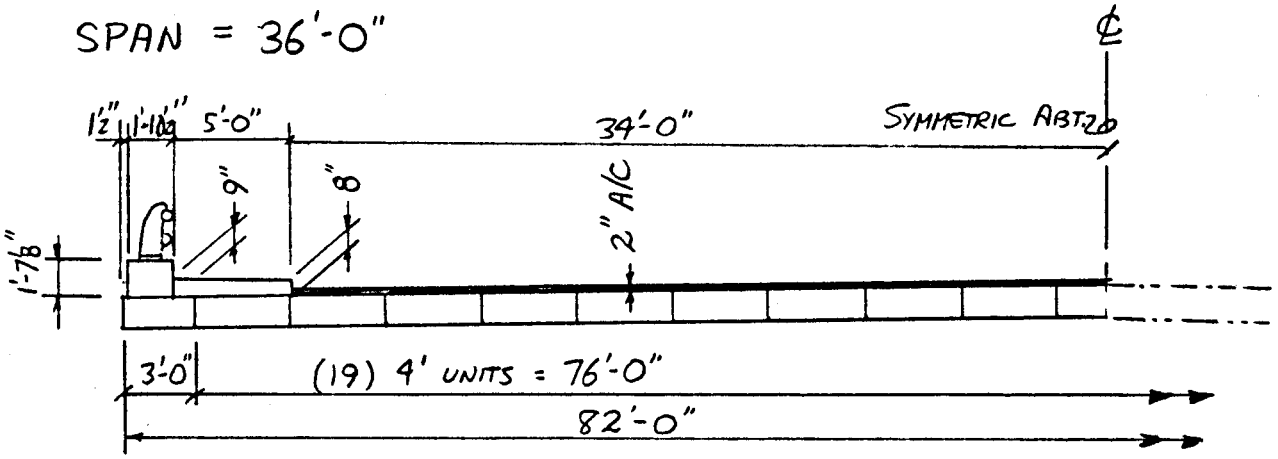
project WIDEN BRDWY no. 83039
client COM design RJ date 5/84
subject GIRDER DESIGN checked date

II. SUPERSTRUCTURE CROSS SECTION

SPAN = 36'-0"



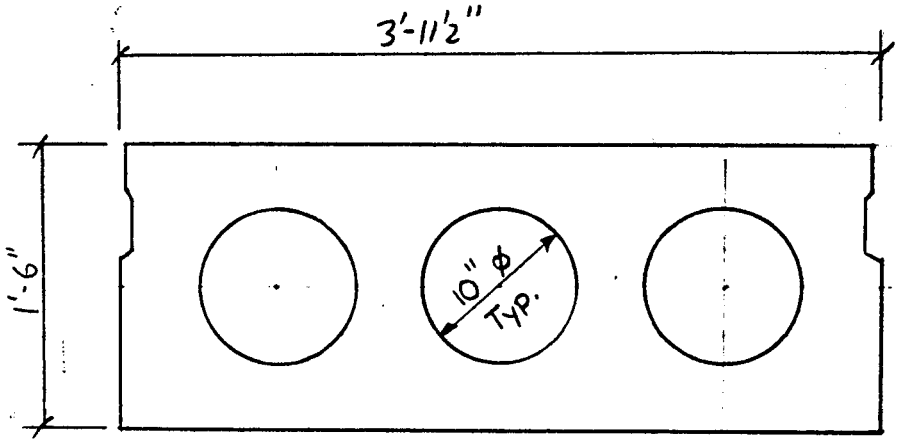
USE AASHTO/PCI "STANDARD PRESTRESSED CONCRETE SLABS" (sht. 3)

TYPE SIII-48

$A = 620\ in^2$

$I = 21855\ in^4$

$\bar{Y} = 9\ in$

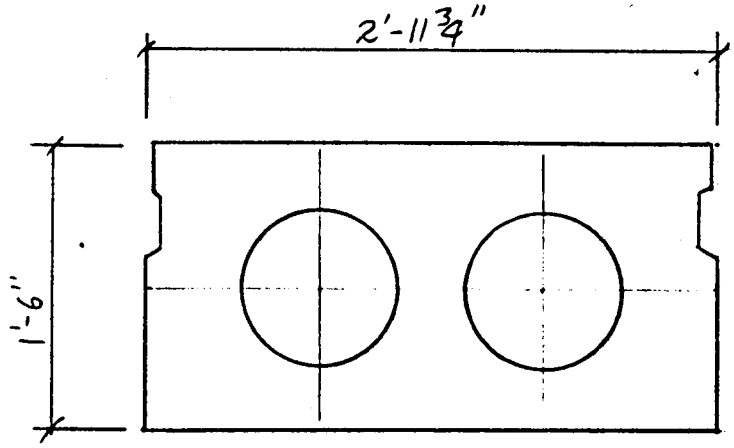


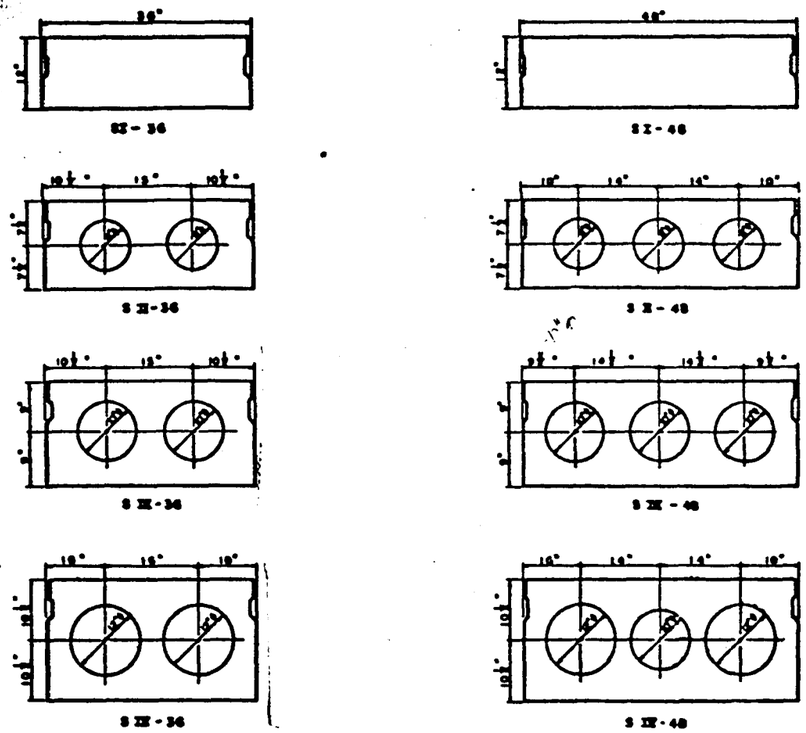
TYPE SIII-36

$A = 491\ in^2$

$I = 16{,}514\ in^4$

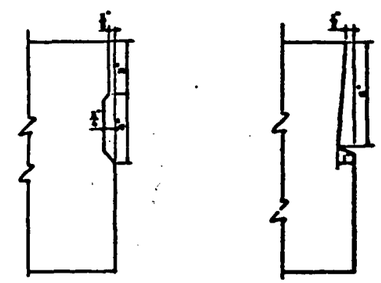
$\bar{Y} = 9\ in$



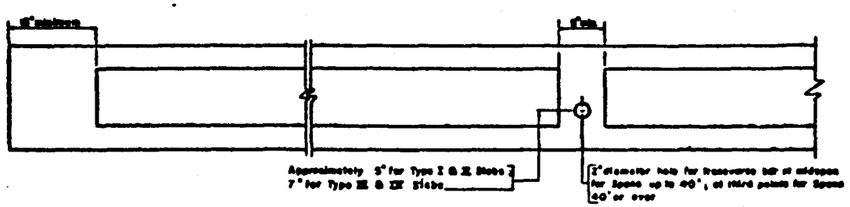


SLAB SECTIONS

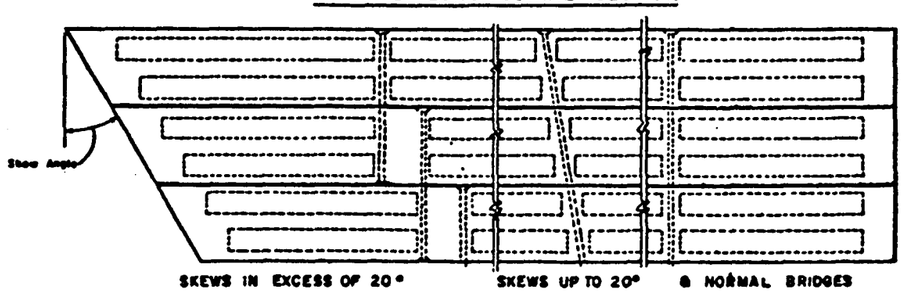
SECTION PROPERTIES					
SECTION	AREA (in²)	MOMENT OF INERTIA (in⁴)	SECTION MODULUS (in³)	APPROXIMATE SPAN (ft.) HS20-S16-44	APPROXIMATE SPAN (ft.) HS20-44
SI-36 (12" x 36")	432	3,164	864	20 - 28	20 - 29
SII-36 (15" x 36")	4398	8,726	1,296	27 - 35	28 - 38
SIII-36 (18" x 36")	494	16,514	1,838	34 - 42	37 - 46
SIV-36 (21" x 36")	630	28,747	2,452	41 - 49	46 - 54
SI-48 (12" x 48")	576	6,912	1,152	20 - 28	20 - 29
SII-48 (15" x 48")	5862	12,697	1,728	27 - 35	28 - 38
SIII-48 (18" x 48")	628	21,888	2,428	34 - 42	37 - 46
SIV-48 (21" x 48")	703	54,947	3,287	41 - 50	46 - 55



SHEAR KEYS



TYPICAL LONGITUDINAL SECTION



TYPICAL PLAN

NOTE
THE SCALE OF THIS PRINT IS ½ THAT OF THE ORIGINAL DRAWING. FOR EXAMPLE:
INDICATED SCALE 3"=1'-0" SHOULD BE READ 1½"=1'-0"
INDICATED SCALE 1/4"=1'-0" SHOULD BE READ 1/8"=1'-0"

GENERAL NOTES

SPECIFICATIONS: "AASHO Standard Specifications for Highway Bridges" Current edition "Criteria for Prestressed Concrete Bridges, US Bureau of Public Roads", 1954; Tentative Recommendations for Prestressed Concrete by ACI - ASCE Joint Committee 323, and any subsequent revisions approved by the Committee on Bridges and Structures of the AASHO.

LIVE LOAD: All highway live loads as specified in the AASHO Standard Specifications for Highway Bridges. Live loads shall be distributed as specified in the AASHO Standard Specifications for Highway Bridges.

PURPOSE: The purpose of the standards shown on this sheet shall be to establish a limited number of simple, practical sections leading to uniformity and simplicity of forming and production methods. These standards shall be applicable to all conditions of highway bridge loading and usage within the approximate span limits indicated in the SUMMARY OF SECTIONS on the sheet. The purpose is specifically not to disrupt or supplant established prestressed concrete slab practice utilizing present plant or forms. Similar sections with minor dimensional variations, manufactured with established plant facilities, which meet structural and geometrical requirements of a specific project may be substituted upon submission by the producer of the data necessary to show compliance with the requirements of the job and upon approval of the substitution by the engineer. Further, the purpose is not to supercede other standard sections adopted by the AASHO and PCI, but rather to complement these standards.

SPAN LIMITS: Span limits shown are approximate only and are not a rigid limitation of the section. The limits shown are based on f'c equal to 4000 psi; f'c equal to 5000 psi, 28 foot roadway, an allowance of 30 pounds per square foot for surfacing, the use of straight prestressing, and allowable stresses as given in the design specifications. The upper span limits may be extended by reduced loading, increased concrete strength, use of light weight concrete, draped tendons, or other approved means within the limits of the design specifications.

CONCRETE: Recommended minimum strength for concrete in slabs are f'c = 5000 psi, at transfer of stressing force, f'ci = 4000 psi. Concrete of greater or less compressive strength, but not less than f'c = 4000 psi, may be used, in which case allowable working stresses and resulting safety of the slabs will be based upon the actual concrete specifications for the particular project.

PRESTRESSING REINFORCEMENT: Prestressing reinforcement shall generally be designed for particular projects or for prevailing bridge practices and available manufacturing facilities.

Materials for prestressing reinforcement may be any of the materials specified by governing specifications or subsequent developments by manufacturers which have generally been accepted in common prestressed practice.

END BLOCKS: The slabs shown utilize end blocks 15" long which have proven satisfactory in many installations. The length of end blocks may be increased to accommodate local plant facilities or particular job requirements. Sufficient mild steel reinforcement should be provided in end blocks to resist the tensile forces due to concentrated prestressing loads.

DIAPHRAGMS: Diaphragms cast within the slab are recommended at midspan for spans up to 40 feet and at third points for spans 40 feet or over.

LATERAL TIES: Lateral ties shall be provided through the diaphragms in the positions indicated. Each tie shall be equivalent to a 1¼" mild steel bar tensioned to 30,000 pounds or an equal force applied by lateral tensioning of high strength tendons. Tension in 1¼" mild steel may be applied by torquing to approximately 600 foot - pounds.

SHEAR KEYS: After lateral ties have been placed and tightened, shear keys shall be filled with high strength, non - shrinking mortar.

FORMS: The use of steel forms on concrete. Rounded casing beds is recommended.

CHAMFERS AND CORNERS: All exposed corners shall be chamfered ¾" or rounded to ¾" radius.

FINISH: Tops shall be given a broom finish, normal to centerline of roadway.

HANDLING: In handling, the slabs must be maintained in an upright position at all times and must be picked up only by means of approved devices near the ends of the slabs.

MILD STEEL REINFORCING, BEARING PADS, ANCHORAGES AND MISCELLANEOUS DETAILS: All details not shown or specified herein shall be designed for particular job requirements and shall be in accordance with applicable job specifications.

JOINT COMMITTEE
AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS
COMMITTEE ON BRIDGES AND STRUCTURES
AND
PRESTRESSED CONCRETE INSTITUTE

STANDARD PRESTRESSED CONCRETE SLABS FOR HIGHWAY BRIDGE SPANS UP TO 55 FT.

SUBMITTED BY

M. E. Deane — George L. Jenkins
H. B. Schultz — Chas. C. Zollman
[illegible] — W. J. Talbot by [illegible]

FOR A.A.S.H.O. — FOR P.C.I.

14887

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project WIDEN BRDWY no. 83039
client COM design RT date 5/84
subject GIRDER DESIGN checked date

III. S-III-48 DESIGN

A. DEAD LOADS

GIRDER:	(620/144)(0.15)	= 0.646 KLF
2" A/C:	(4')(.025 KSF)	= 0.100
FWS:	(4)(.025)	= 0.100
		0.846 KLF

B. LIVE LOADS

1. CURB TO CURB WIDTH = 68'

$N_L = 68/12 = 5.67 \Rightarrow$ 5 LANES

2. TRANSVERSE DISTRIBUTION [AASHTO 1.3.1(D), PP. 39-40]

$N_G = [(19)(4)+(2)(3)]/4 = 20.5$ (4' UNITS)

$W = 82'$ $K = 0.8$ (AASHTO P. 40)

$C = K(W/L) = (0.8)(82)/36 = 1.82$ (<3)

$S = [(12)(5)+9]/20.5 = 3.37$

$D = 5 + \frac{S}{10} + [3-(2)(5)/7]\left[1 - \frac{1.82}{3.0}\right]^2 = 5.74$

LOAD FRACTION $= \frac{S}{D} = 3.37/5.74 = 0.59$ (FOR 4' UNITS)

USE $0.59 \times \frac{3}{4} = 0.44$ (FOR 3' UNITS)

3. LANE REDUCTION - NOT APPLICABLE

4. IMPACT, $I = 50/(36+125) = 0.31$ - USE $I = 0.30$

5. LIVE LOAD MOMENT [AASHTO, APP. A, P 453]

$M_{LANE} = 378.9$ K-FT

$M_{UNIT} = (378.9/2)(0.59)(1.30) = 145.3$ K-FT/UNIT

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project WIDEN BRDWY no. 83039
client COM design RV date 5/84
subject GIRDER DESIGN checked date

III. SIII-48 DESIGN

C. DEAD LOAD MOMENTS

1. GIRDER, $M_{\mathbb{C}} = (.646)(36)^2/8 = 104.7^{K\text{-}FT}$

2. SUPERIMPOSED DEAD LOADS

a. SIDEWALK $[(8+9)(5.0)/(2)(12)](0.15)/(20.5/2) = 0.052^{KLF}$

b. CURB $(1.875)(1.594)(0.15)/(20.5/2) = 0.044$

c. A/C 0.100

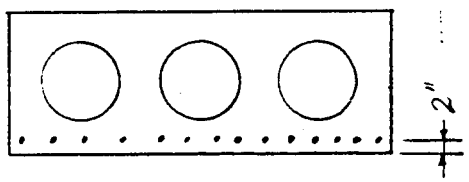
d. FWS 0.100

0.296 KLF

e. $M_{\mathbb{C}} = (0.296)(36)^2/8 = 47.9^{K\text{-}FT}$

D. PRESTRESSING

1. TRY 12 STRANDS



2. $M_{GDR} = 104.7^{K\text{-}FT}/UNIT$

3. $M_T = 104.7 + 47.9 + 145.3 = 297.9^{K\text{-}FT}/UNIT$

4. ASSUME RELEASE STRENGTH $f'_{ci} = 4000$ psi

project: WIDEN BROADWAY RD. BRIDGE @ RWCD no. 83039.0
client: CITY OF MESA (W/REVIEW BY FCDMC) design: RDT date: 05/1984
subject: AASHTO PRESTRESS LOSSES checked date:

PRE-TENSIONING LOSSES

NUMBER OF STRANDS = 12 STRAND SIZE = .1530 IN**2
CONC. STRENGTH @ RELEASE = 4000. PSI STRAND STRENGTH = 270. KSI
GIRDER AREA = 620.00 IN**2 GIRDER MOI = 21855. IN**4
GIRDER N.A. TO CGS = 7.00 IN RELATIVE HUMIDITY = 40. %

THE FOLLOWING MOMENTS ARE AT 18.00 FT. FROM THE LEFT SUPPORT
GIRDER DEAD LOAD MOMENT = 104.7 K-FT
OTHER DEAD LOAD MOMENT = 47.9 K-FT

SH = 11000. PSI
ES = 6565. PSI
CRC = 8855. PSI
CRS = 13403. PSI
==========
TOTAL PRESTRESS LOSS = 39823. PSI

TRANSFER AT 18. HOURS AFTER TENSIONING
EFFECTIVE PRESTRESS AFTER TRANSFER = .652 X 270. = 175.95 KSI

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project WIDEN BRDWY no. 83039
client COM design RT date 5/84
subject GIRDERS checked date

III. SIII-48 DESIGN

D.5. EXTREME FIBER STRESSES

a. ALLOWABLES [AASHTO 1.6.6.(B), p 120]

INITIAL TENSION $= 3\sqrt{4000} = 190$ psi (NO BONDED REINF)

OR $7.5\sqrt{4000} = 474$ psi (W/BONDED REINF.)

INITIAL COMPRESSION $= (0.6)(4000) = 2400$ psi

FINAL TENSION $= 6\sqrt{5000} = 424$ psi (W/BONDED REINF.)

OR $= 0$ (NO BONDED REINF.)

FINAL COMPRESSION $= (0.4)(5000) = 2000$ psi

b. ACTUAL STRESSES

90% OF ELASTIC SHORTENING $P_o = 12 \times .153 \times .7 \times 270 = 34$

$P_i = (12)(.153)[(0.7)(270) - 10] = 329^K$

$P_f = (12)(.153)[(0.7)(270) - 39.823] = 274^K$

$e = 9 - 2 = 7''$ $\quad c = 9''$

$M_{i(P/S)} = (329)(7/12) = 191.9^{K\text{-}FT}$ ✓

$M_{f(P/S)} = (274)(7/12) = 159.8^{K\text{-}FT}$ ✓

INITIAL @ ℄ $= \frac{P_i}{A_g} \pm \frac{M_i c}{I} \mp \frac{M_g c}{I}$

$\frac{329}{620} \pm \frac{(191.9)(12)(9)}{21855} \mp \frac{(104.7)(12)(9)}{21855}$

$0.531 \pm 0.948 \mp 0.517$ ✓

$f_{bottom} = 0.962^{KSI} < 2400$ ✓

$f_{top} = 0.100^{KSC} > 0$ ✓

Cont...

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project WIDEN BRDWY no. 83039
client COM design RJ date 5/84
subject GIRDERS checked date

III. SIII-48 DESIGN

D.5.b. ACTUAL STRESSES (Cont.)

INITIAL @ ENDS (NO GIRDER MOMENT)

$= 0.531 \pm 0.948$

$f_{bottom} = 1.479^{KSI}$ (< 2.400 ✓)

$f_{top} = -0.417^{KSI}$ (< -.474 - TOP BONDED REINF. REQ'D)

FINAL @ ℄ $= \frac{P_f}{A} \pm \frac{M_f C}{I} \mp \frac{M_T C}{I}$

$\frac{274}{620} \pm \frac{(159.8)(12)(9)}{21855} \mp \frac{(297.9)(12)(9)}{21855}$

$0.442 \pm 0.790 \mp 1.472$

$f_{bottom} = .442 + .790 - 1.472 = -0.241^{KSI}$ (<-.424 ✓)

$f_{top} = .442 - .790 + 1.472 = 1.124^{KSI}$ (< 2000 ✓)

FINAL @ ENDS (NO SUPERIMPOSED MOMENT)

$= 0.442 \pm 0.790$

$f_{bottom} = 0.442 + 0.790 = 1.232^{KSI}$ (< 2.000 ✓)

$f_{top} = 0.442 - 0.790 = -0.348^{KSI}$ (< -.424 ✓)

6. CHECK ULTIMATE STRENGTH [AASHTO 1.6.9, p 126]

$M_U = 1.3[(104.7 + 47.9) + 1.67(145.3)] = 513.8^{K\text{-}FT}$

$d = 18'' - 2 = 16''$

$P^* = (12)(.153)/(47.5)(16) = .00242$

$f_{SU}^* = 270[1 - (.5)(.00242)(270)/5] = 252.39^{KSI}$

Cont...

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project BRDWY WIDENING no. 83039
client COM design RT date 5/84
subject GIRDERS checked date

III. STII-48 DESIGN

D.6. ULT STR (Cont.)

CHECK N.A.: $(1.4)(16)(.00242)(252.39)/5 = 2.74''$

MIN FLG THKNS $= (18-10)/2 = 4''$ (>2.74 ∴ N.A. WITHIN FLG. ✓)

$M_U = (12)(.153)(252.39)(16)\left[1-(0.6)(.00242)(252.39)/5\right]/12$

$= 572.6^{K\text{-}FT}$ (> 513.8 ✓)

7. CHECK REINF. INDEX [AASHTO 1.6.10(A), PP. 126-127]

$(.00242)(252.39)/5 = 0.12$ (< 0.30 ✓)

USE 12 - 1/2"Ø STRANDS

8. CHECK MINIMUM STEEL [AASHTO 1.6.10(B), P. 127]

$f_r = 7.5\sqrt{5000}/1000 = 0.530^{KSI}$

FINAL, BOTTOM STRESS DUE TO P/S ALONE

$P_f = 274^K$ (sht. 7)

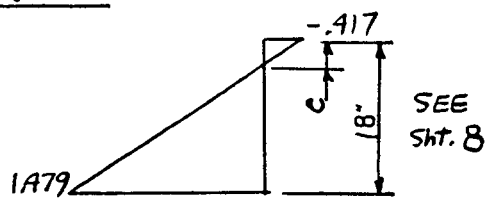
$f_b = 274/620 + (274)(7)(9)/21855 = 1.232^{KSI}$

$M_{CR} = (.530 + 1.232)(21855)/(12)(9) = 356.6^{K\text{-}FT}$

$1.2M_{CR} = (1.2)(356.6) = 427.9^{K\text{-}FT}$ (< 572.6 ✓)

9. BONDED REINF. TO RESIST TENSION STRESSES

a. TOP OF GIRDER



$c = (.417)(18)/(.417+1.479) = 3.96''$

$F_T = (.417)(47.5)(3.96)/2 = 39.21^K$

$A_{BS} \geq 39.21/20 = 1.96\ in^2$ USE 7 #5 BARS, TOP

Cont....

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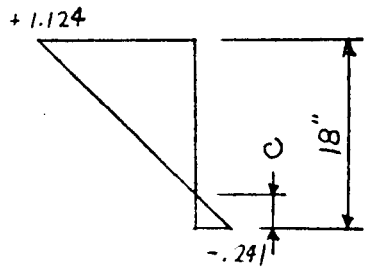
project WIDEN BRDWY no. 83639
client COM design RJ date 5/84
subject GIRDERS checked date

III. SIII-48 DESIGN

D.9. BONDED REINF. (Cont.)

b. BOTTOM OF GIRDER



$C = (.241)(18)/(.241 + 1.124) = 3.18''$

$F_T = (.241)(3.18)(47.5)/2 = 18.19^K$

$A_{BR} = 18.19/20 = 0.91\ in^2$

USE 3 # 5 BARS, BOTTOM

E. SHEAR $b' = 47.5 - (3)(10) = 17.5$

$V_{LL} = (53.3/2)(0.59)(1.3) = 20.44^K$ (AASHTO APP. A, P. 453)

$V_{DL} = (.646 + .296)(36/2) = 16.96^K$

$V_u = 1.3[16.96 + (1.67)(20.44)] = 66.42^K$

$V_{c\,(MIN)} = 1.7\sqrt{5000}(17.5)(16)/1000 = 33.66^K$

$V_u \le \phi(V_c + V_s)$ $\phi = 0.85$

$V_s \ge \frac{V_u}{\phi} - V_c = (66.42/.85) - 33.66 = 44.49^K$

$V_s = A_v f_{sy} d/s$

$A_v/s = V_s/f_{sy}d = 44.49/(40)(16) = 0.070\ in^2/in$

FOR # 5 STIRRUPS $A_v = (2)(.31) = 0.62\ in^2$

$s = 0.62/.070 = 8.92''$

10.2

AT MIDSPAN, $V_{DL} = 0$, FOR SIMPLICITY SAY $V_{LL\,\mathbb{C}} = 20.44$

$V_u = (1.3)(1.67)(20.44) = 44.38^K$

$V_s \ge (44.38/.85) - 33.66 = 18.55^K$

Cont....

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project WIDEN BROWY no. 83039
client COM design RA date 5/84
subject GIRDERS checked date

III. STII-48 DESIGN

E. SHEAR (Cont.)

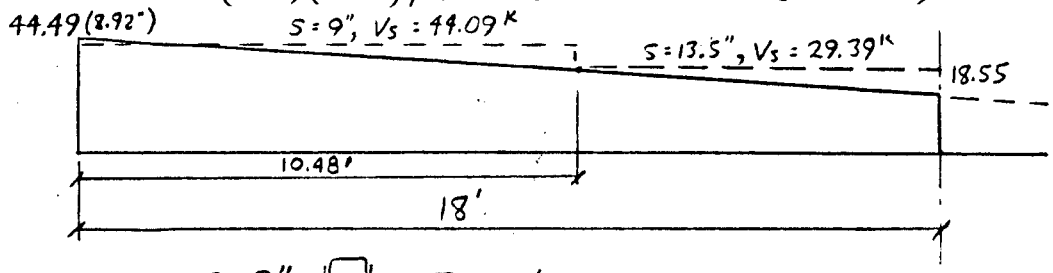
$A_v/s = 18.55/(40)(16) = .029\ in^2/in$

FOR #5 STIRRUPS $A_v = .62\ in^2$

$S = .62/.029 = 21.39''$ ($> .75h = 13.5''$) (@ $S = 13.5''$, $V_s = 29.39^k$)

MIN. AREA $A_v/s = (50)(17.5)/40000 = .022$ ($< .029$)

V_s:



USE #5 STIRRUPS @ 9" FULL LENGTH

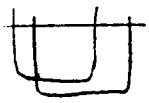
F. ANCHORAGE ZONE [AASHTO 1.6.15, p. 130-131]

P_i (@ TRANSFER) = 329^k (Sht. 7)

$A_{AZ} = (.04)(329)/20 = 0.66\ in^2$

$d/4 = 16/4 = 4''$

USE 4 #4's THUS



$A_{AZ} = (4)(.20) = 0.80\ in^2$

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project WIDEN BRDWY no. 83039
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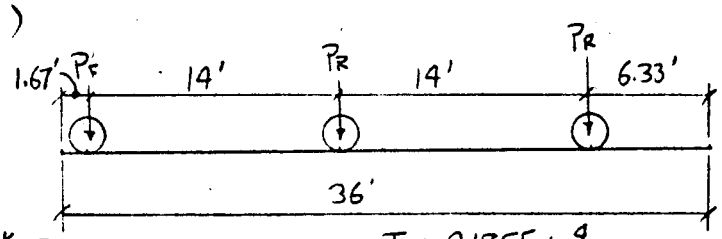
III. SIII-48 DESIGN (Cont.)

G. DEFLECTIONS

POSITION TRUCK FOR M_{MAX}



$P_F = (8/2)(.59)(1.30) = 3.07^k$
$P_R = (32/2)(.59)(1.30) = 12.27^k$ } PER UNIT

$I = 21855 \text{ in}^4$
$E_c = 4031{,}000 \text{ psi}$

1. LIVE LOAD DEFLECTION
   FOR ABOVE LOADS & GEOMETRY @ ℄ SPAN
   BY CALCULATOR PROGRAM $\Delta_{LL} = -0.355'' \downarrow (L/1218)$

2. DEAD LOAD DEFLECTION

$$\Delta_{DL} = \frac{(5)(.646+.296)(36)^4(1728)}{(384)(4031)(21855)} = -0.404'' \downarrow$$

3. PRESTRESS DEFLECTION (FINAL)

$$\Delta_{P/S} = \frac{(274)(7)(36\times12)^2}{(8)(4031)(21855)} = 0.508'' \uparrow$$

$$\Delta_{D+L+P/S} = -0.251'' \downarrow (L/1721)$$

$$\Delta_{D+P/S} = 0.104'' \uparrow$$

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project WIDEN BRDWY no. 83039
client COM design RV date 5/84
subject GIRDERS checked date

IV. SIII-36 DESIGN

A. GIRDER DEAD LOAD

$(491/144)(0.15) = 0.511^{KLF}$

$M_G = (.511)(36)^2/8 = 82.9^{K\text{-}FT}$

B. LIVE LOADS

1. LOAD FRACTION = 0.44 (Sht. 4)
2. IMPACT = I = 0.30 (Sht. 4)
3. LIVE LOAD MOMENT

$M_{UNIT} = (378.9/2)(0.44)(1.30) = 108.4^{K\text{-}FT}$

C. SUPERIMPOSED DEAD LOADS

1. SIDEWALK (Sht. 5) $(0.052)(3/4) = .039^{KLF}$
2. CURB (Sht. 5) $(0.044)(3/4) = .033$
3. A/C $(3')(.025) = .075$
4. FWS " $= .075$

0.222^{KLF}

5. $M_{\mathbb{C}} = (0.222)(36)^2/8 = 36.0^{K\text{-}FT}$

D. PRESTRESSING

1. TRY 9 - ½"ø STRANDS
2. $M_T = 82.9 + 108.4 + 36.0 = 227.3^{K\text{-}FT}$
3. ASSUME $f'_{ci} = 4000$ psi

project: WIDEN BROADWAY RD. BRIDGE @ RWCD no. 83039.0
client: CITY OF MESA (W/REVIEW BY FCDMC) design: RDT date: 5/84
subject: AASHTO PRESTRESS LOSSES checked date:

PRE-TENSIONING LOSSES

NUMBER OF STRANDS = 9 STRAND SIZE = .1530 IN**2
CONC. STRENGTH @ RELEASE = 4000. PSI STRAND STRENGTH = 270. KSI
GIRDER AREA = 491.00 IN**2 GIRDER MOI = 16514. IN**4
GIRDER N.A. TO CGS = 7.00 IN RELATIVE HUMIDITY = 40. %

THE FOLLOWING MOMENTS ARE AT 18.00 FT. FROM THE LEFT SUPPORT
GIRDER DEAD LOAD MOMENT = 82.9 K-FT
OTHER DEAD LOAD MOMENT = 36.0 K-FT

SH = 11000. PSI
ES = 6180. PSI
CRC = 8267. PSI
CRS = 13675. PSI
==========
TOTAL PRESTRESS LOSS = 39122. PSI

TRANSFER AT 18. HOURS AFTER TENSIONING
EFFECTIVE PRESTRESS AFTER TRANSFER = .653 X 270. = 176.33 KSI

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project WIDEN BRDWY no. 83039
client COM design RT date 5/84
subject GIRDERS checked date

IV. STII-36 DESIGN

D. PRESTRESSING (Cont.)

4. EXTREME FIBER STRESSES

a. ALLOWABLES - SEE SHT. 7

b. ACTUAL STRESSES

90% OF ELASTIC SHORTENING

$P_i = (9)(.153)[(0.7)(270) - 10] = 246^K$

$P_f = (9)(.153)[(0.7)(270) - 39.122] = 206^K$

$e = 7''$ $c = 9''$

$M_i = (246)(7/12) = 143.5^{K\text{-}FT}$

$M_f = (206)(7/12) = 120.2^{K\text{-}FT}$

c. INITIAL @ ℄

$f_b = 900$ psi (< 2400 ✓)

$f_t = 104$ psi (> 0 ✓)

d. FINAL @ ℄

$f_b = -279$ psi (< -424 ✓)

$f_t = 1120$ psi (< 2000 ✓)

e. INITIAL @ ENDS

$f_b = 1442$ psi (< 2400 ✓)

$f_t = -438$ psi (< -474 ✓)

f. FINAL @ ENDS

$f_b = 1208$ psi (< 2000 ✓)

$f_t = -367$ psi (< -424 ✓)

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client COM design RT date 5/84
subject GIRDERS checked date

III. STII-36 DESIGN

D.6. CHECK ULT. STR. [AASHTO 1.6.9, p. 126]

$M_u = 1.3[(82.9 + 36.0) + (1.67)(108.4)] = 389.9$ K-FT/3FT. UNIT

$d = 18 - 2 = 16''$

$P^* = (9)(.153)/(35.5)(16) = 0.00242$

$f^*_{su} = 270[1 - (.5)(.00242)(270)/5] = 252.33$ KSI

CHECK N.A.: $(1.4)(16)(.00242)/5 = 2.74''$ (✓ N.A. WITHIN FLANGE)

$M_u = (9)(.153)(252.33)(16)[1 - (.6)(.00242)(252.33)/5]/12$

$= 429.3$ K-FT/UNIT (> 389.9 ✓)

7. CHECK MINIMUM STEEL [AASHTO 1.6.10(B), p.127]

$f_r = 7.5\sqrt{5000}/1000 = 0.53$ KSI

FINAL, BOTTOM STRESS DUE TO P/S ALONE

$P_f = 206^K$ (sht. 15)

$f_b = 206/491 + (206)(7)(9)/16514 = 1.205$ KSI

$M_{CR} = (.53 + 1.205)(16514)/(12)(9) = 265.4$ K-FT

$1.2 M_{CR} = (1.2)(265.4) = 318.4$ K-FT (< 429.3 ✓)

8. CHECK REINF. INDEX

$(.00242)(252.33)/5 = 0.12$ (< 0.30 ✓)

USE 9 - ½"Ø STRANDS

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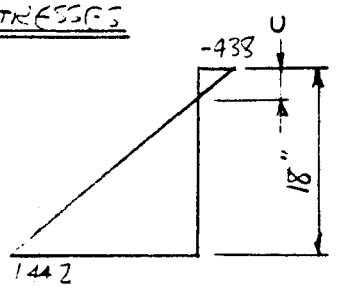
client COM design RJ date 5/84
subject GIRDERS checked date

III. STII-36 DESIGN

D. 9. BONDED REINF TO RESIST TENSION STRESSES

a. TOP OF GIRDER



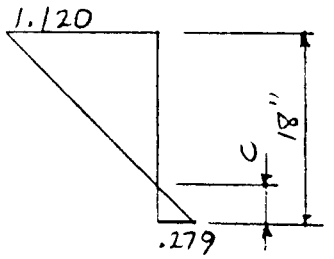
$c = (438)(18)/(438+1442) = 4.19''$

$F_T = (.438)(35.5)(4.19)/2 = 32.6^K$

$A_{BR} = 32.6/20 = 1.63\ in^2$

USE 6 #5 TOP

b. BOTTOM OF GIRDER



$c = (.279)(18)/(.279+1.120) = 3.59''$

$F_T = (.279)(35.5)(3.59)/2 = 17.78^K$

$A_{BR} = 17.78/20 = 0.89\ in^2$

USE 3 #5 BOTTOM

E. SHEAR

$b' = 35.5 - (2)(10) = 15.5''$

$V_{LL} = (53.3/2)(0.44)(1.30) = 15.24^K$ (AASHTO APP. A, p.453)

$V_{DL} = (.511+.222)(36/2) = 13.19^K$

$V_U = 1.3\left[(13.19)+(1.67)(15.24)\right] = 50.25^K$

$V_{C(MIN)} = (1.7)\sqrt{5000}\,(15.5)(16)/1000 = 29.81^K$

$V_U \le \phi(V_C + V_S) \qquad \phi = 0.85$

$V_S \ge \frac{V_U}{\phi} - V_C = (50.25/.85) - 29.81 = 29.30^K$

Cont.....

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III. SIII-36 DESIGN

E. SHEAR (Cont.)

$V_s = A_v f_{sy} d / s$

$A_v/s = V_s / f_{sy} d = 29.30/(40)(16) = .046 \text{ in}^2/\text{in}$

FOR #5 STIRRUPS: $A_v = (2)(.31) = 0.62 \text{ in}^2$

$s = .62/.046 = 13.5''$

MAX SPACING $= .75h = (.75)(18) = 13.5''$

USE #5 STIRRUPS @ 13'2" FULL LENGTH

F. ANCHORAGE ZONE [AASHTO 1.6.15, pp 130-131]

P_i (@ TRANSFER) $= 246^k$ (Sht. 15)

$A_{az} = (.04)(246)/20 = 0.49 \text{ in}^2$

$d/4 = 16/4 = 4''$

USE #4 ⊔ ($A_p = .80 \text{ in}^2$ ✓)

G. DEFLECTIONS

1. LIVE LOAD (FACTOR Δ FOR 4' BOX, sht. 12)

$(.44/.59)(21855/16514)(-.355) = -0.350'' \downarrow (L/1233)$

2. DEAD LOAD

$(5)(.511 + .222)(36)^4(1728)/(384)(4031)(16514) = -0.416'' \downarrow$

3 P/S LOAD (FINAL)

$(206)(7)(36 \times 12)^2/(8)(4031)(16514) = 0.505'' \uparrow$

$D + P/S = .089'' \uparrow$

$D+L+P/S = -0.261'' \downarrow (L/1654)$